2000 NPS Science

▲ **A National Park Service snorkeler** and U.S. Geological Survey data recorder survey freshwater mussels in the Upper Delaware River. The initial phase of the mussel study has revealed the presence of dwarf wedgemussel in Pennsylvania where it was thought to be extirpated. Monitoring changes in the populations and distribution of species found in the survey will provide valuable information about the health of the river ecosystem.

We will lose the wildness, the very nature of our parks, if we don't understand them. If we don't truly understand them, we won't be able to speak authoritatively for them, and we won't know how to restore them. We will ultimately lose them if we can't educate people about what parks require for survival.

—Mike Soukup
Associate Director, Natural Resource Stewardship and Science

A fundamental and critical role of the National Park Service is acquiring and considering scientific information to preserve park natural resources for the American public. The Inventory and Monitoring (I&M) Program has been at work since the early 1990s gathering baseline resource information and monitoring conditions over time. New information may suggest the need for more sophisticated studies to examine why conditions have changed and how those changes are affecting ecological processes. The Park Service relies on its own resource managers and an expanding network of partners to gather and focus such information on park management questions. Certainly much more information is needed to thoroughly understand the natural systems in the national parks. Nevertheless, as the articles for 2000 indicate, the knowledge being developed through science is providing valuable insights for the long-term care of park natural resources.

Gathering Usable Data

Inventories benefit resource management efforts in the Northeast Region

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The value of scientific inventories as a resource management tool in national parks is that they create baseline data for future planning and reflect the health of ecosystems. With information yielded by a systematic sampling of a park's plants and animals, resource managers know they will have convincing evidence when they evaluate the effects of proposed construction, land use changes, or other developments within or near their borders. In fact, as microcosms of their respective regions, national parks can use their surveys and monitoring to provide an early-warning system that benefits the inhabitants of entire watersheds. During 2000 the breadth of these inventories improved as a result of the Natural Resource Challenge, which provided $7 million to the Servicewide Inventory and Monitoring Program. By combining these funds with regional and park funds, several of the national parks in the Allegheny and Chesapeake Clusters of the Northeast Region implemented or began developing policies to protect rare, threatened, or endangered species that had been identified in previous inventories. Moreover, some studies that were initiated in 2000 have already yielded surprises.

"Scientific inventories ... in national parks ... create baseline data for future planning and reflect the health of ecosystems."

Among the species in the Northeast that will benefit from investigative surveys is the bog turtle (*Clemmys muhlenbergii*). A study conducted in 1998 and 1999 identified likely habitat for this federally endangered species in the Delaware Water Gap National Recreation Area and confirmed its presence in the park. However, researchers observed that the open marshland needed by the turtle was being invaded by purple loosestrife (*Lythrum salicaria*), a common exotic whose high canopy crowds out lower-growing native plants. In 2000 the park began implementing a long-term strategy designed to reverse this trend. Two kinds of beetles (leaf-eaters and root-borers) that are biological enemies of the loosestrife were released. Ongoing monitoring of both the bog turtle population and the loosestrife will enable resource managers to evaluate the effectiveness of their strategy and to modify it if needed.

Additional opportunities to provide or protect habitat for rare species are being revealed by inventories in West Virginia. Although the species have not yet been identified, researchers have verified that bats are using the cavelike habitat of the abandoned coal mines found in the New River Gorge National River/Gauley River National Recreation Area. Three federally endangered species of bats occur in West Virginia, two of which (gray myotis [*Myotis grisescens*] and Indiana myotis [*Myotis sodalis*]), have previously been found in abandoned deep mines. The third, the Virginia big-eared bat (*Plecotus townsendii virginianus*), is typically found in caves and uses rock shelters in other parts of its range. At least two other rare species, the eastern small-footed bat (*Myotis leibii*) and Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), are occasionally or regularly associated with abandoned underground mines. When the study is completed, resource managers hope to identify specific portals that are being used by one or more of these at-risk species. Gating these portals will reduce hazards to the public, continue to make mines accessible to bats, and reduce disturbances to bat colonies due to recreational entry.

The value of combining information gathered from several surveys was shown in Colonial National Historical Park near Williamsburg, Virginia. During 2000, a small community of a threatened wetland plant, sensitive joint-vetch (*Aeschynomene virginica*), was rediscovered in the park during a survey by the Virginia Division of Natural Heritage of the Department of Conservation and Recreation; the presence of this species had not been documented in that area since 1939. Fortunately a two-year, parkwide inventory of invasive flora had disclosed that common reed (*Phragmites australis*) was growing nearby. Knowing the relative location and density of these two species has prompted park management to target that area for treatment in 2001 to help ensure that the rare plant survives.

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▲ **Capable of siphoning and straining** up to 5 gallons of water a day, freshwater mussels contribute to water quality and clarity by filtering algae, bacteria, and particulate matter from the water. These five mussels, representing four species, were documented during a survey along 73 miles of the Upper Delaware River. They are valuable indicators of ecosystem health.

Of course, because they are so recent many inventories begun or conducted in 2000 have not yet affected management policies or monitoring strategies—but they will. Perhaps most dramatic are surveys that yield discoveries reflecting the health of ecosystems. Knowing that freshwater mussels are the most rapidly declining animal group in the United States and that they serve as useful barometers of environmental health, the National Park Service and the U.S. Geological Survey began a two-year study in July 2000 to determine the diversity, abundance, and distribution of freshwater mussels in the Upper Delaware Scenic and Recreational River. The researchers are using geographic information system technology to create maps of mussel species distribution and abundance that incorporate data from each 200-meter snorkel survey section along 73 miles of river. Among the eight species found so far, three are listed as endangered, threatened, or proposed endangered at the state or federal level. These three (all indicators of good water quality) are the dwarf wedgemussel (*Alasmidonta heterodon*), thought to have been extirpated in Pennsylvania; the brook floater (*Alasmidonta varicosa*); and the eastern pearlshell (*Margaritifera margaritifera*), which had not been documented in the Delaware River basin in Pennsylvania since 1919. As part of the study, researchers will establish permanent monitoring transects to allow for long-term assessment of trends in mussel populations. This ongoing monitoring will give park personnel an additional indicator of water quality and better enable them to detect changes in ecosystem health in a river upon which millions of people rely for drinking water.

Surveys in 2000 have also revealed species that are intriguing because they are being found in some parks for the first time. Examples include a crayfish (*Cambarus acuminatus*) in Valley Forge National Historical Park, the mountain dusky salamander (*Desmognathus ochrophaeus*) in Delaware Water Gap National Recreation Area, and the northern leopard frog (*Rana pipiens*) in Gettysburg National Military Park (NMP). While conducting an inventory in 1999 and 2000 at both Gettysburg NMP and Eisenhower National Historic Site, researchers also documented four new species of bat for those areas: northern or long-eared myotis (*Myotis septentrionalis*), eastern pipistrelle (*Pipistrellus subflavus*), red bat (*Lasiurus borealis*), and hoary bat (*Lasiurus cinereus*). These preliminary findings suggest the need to conduct a population assessment and to continue monitoring those sites where these animals are being found.

Because factors such as urban sprawl, changing land and water use, and encroachment by dominant plants (both native and exotic) will continue to affect each region's biodiversity, the role of the National Park Service as a protector of natural resources has never been more critical. As researchers analyze and monitor the newfound species in the coming months, their insights will enhance the ability of managers throughout the Northeast Region to plan proactively and to educate the public about the delicate ecosystems in the parks.

Dan Foster honored for resource monitoring

Award-Winner Profile

The Trish Patterson/Student Conservation Association Award for Resource Management in a Small Park went to Dan Foster, Chief of Resource Management of Nez Perce National Historical Park and Big Hole National Battlefield. Dan was recognized for his exemplary work in developing an effective, practical, and sensible natural resource management program for the 38 widely dispersed park units in Washington, Oregon, Idaho, and Montana. The natural and cultural resources in the units are closely intertwined in the stories of the Nez Perce War, the Lewis and Clark Expedition, western missionary history, and the fur trade, and face problems related to encroachment, habitat loss, exotic species, water quality, and lack of knowledge.

"In looking at the problems we faced in widespread park sites, limited [staff], and long intervals of return," Dan explained, "we decided that the best monitoring of park resources was through the use of digital photography." With the help of Lewis and Clark College, Clearwater National Forest, the Nez Perce Tribe of Idaho, the National Park Foundation, and Canon U.S.A., Dan established a three-year project to document change to park resources. The project compares historical photographs with current conditions through digital videography and computer technology. He also acquired funding for and coordinated high-resolution aerial photography of Bear Paw Battlefield to help create detailed digital maps for the park geographic information system. Along with the Nez Perce Tribe and the U.S. Geological Survey, he secured funds and coordinated a baseline water quality study on five of the park units.

Dan relies heavily on partners and park neighbors to address many park resource management issues. He does not consider himself a "genius or outstanding manager," but is thankful for working with highly committed coworkers who care deeply about resource preservation. Winning the award encourages Dan that the work he and his staff and partners are doing "is recognized and important in other people's minds and hearts. We will keep going."

▲ **Dan Foster,** accompanied by his wife, receives the Trish Patterson/Student Conservation Association Award for Resource Management in a Small Park from Mike Soukup, Associate Director for Natural Resource Stewardship and Science. The award included a $2,000 cash prize and a bronze sculpture of a bison.

Amphibians and abandoned mines spawn collaboration of scientific disciplines

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The critical decline of amphibian populations has gained worldwide attention. Frequently, units of the national park system have little if any baseline data on amphibians and their habitat. Prince William Forest Park (Virginia) was no exception until a partnership evolved between park staff and geologists with the U.S. Geological Survey (USGS).

In 1995 the Cabin Branch Pyrite Mine was reclaimed after years of coordination between the Virginia Department of Mines, Minerals, and Energy and the Geologic Resources Division, Water Resources Division, and other natural resource staff of the National Park Service. After the reclamation, the amphibians gained the attention of the geologists by using numerous pools of surface water designed to minimize acid mine drainage. By 1998 the geologists had teamed up with the resource management staff of the park to initiate monitoring of the amphibians.

"The data … will be invaluable in protecting amphibian communities…."

Monitoring of the amphibians comprises (1) anuran calling surveys, (2) community structure and breeding surveys, (3) identification and digitization of amphibian breeding sites with geographic information systems, (4) development of educational materials, and (5) development of an interactive Web-based training program. With information from the literature, resource management staff developed a monitoring protocol in 1997 and began water sampling in 1998. The protocol prescribes the recording of anuran calls, visual encounter surveys, dipnetting and identification of larvae, and use of egg bags to enumerate hatch success. Monthly grab water samples are analyzed for 67 parameters, including aluminum, copper, lead, and zinc. The USGS conducts soil-pH and geoelectrical surveys, solid material characterization, and radiogenic isotope studies. The data are used for in-depth analyses of site conditions, levels of inorganic constituents, and characterization of surface and groundwater, which will be used to determine the relationship between habitat condition and community structure.

The amphibian monitoring program also includes a dynamic educational component. In 2000, park staff and volunteers developed an amphibian brochure, an intranet page, an interactive CD-ROM, and a detailed training manual. Interpretive staff at the park developed amphibian programs and worked with the resource management staff to expand the programs to local schools.

The park first sought funding for the program from the Science Division of the National Capital Region in 1999 and matched the funds with money from the base funds of the park and funds from the Volunteers-in-Parks Program. From 1997 to 2000, the USGS donated expertise and laboratory analyses valued at approximately $50,000 per year. In 2000, park staff expanded the surveys of anuran calling and amphibian habitat by conducting them throughout the park.

An NPS resource manager and USGS scientist at Prince William Forest Park identify amphibian larvae as part of an extensive baseline survey of park amphibians. Expanded in 2000, the surveys have enabled the park to develop lasting partnerships with scientists, educators, and the public, and to gather substantial data for use in monitoring changes to amphibian populations and habitat.

The success of this partnership is already evident. The park now has unparalleled baseline data on amphibian breeding success, characterization and identification of critical amphibian habitat, and corresponding water chemistry data. The monitoring of amphibians has become an integral part of the park's Inventory and Monitoring Program and has park support for its continuation. Finally, the park developed long-lasting partnerships with scientists, educators, and members of the public who provide continuous feedback for the program as new issues and technologies emerge.

The data, collected by scientists from diverse disciplines, will be invaluable in protecting amphibian communities because they will allow resource managers to monitor changes in these populations and their habitat. As trends are identified, efforts can be focused on particular species or threatened habitats to ensure the highest level of protection for them.

Barred owl displaces northern spotted owl at Olympic

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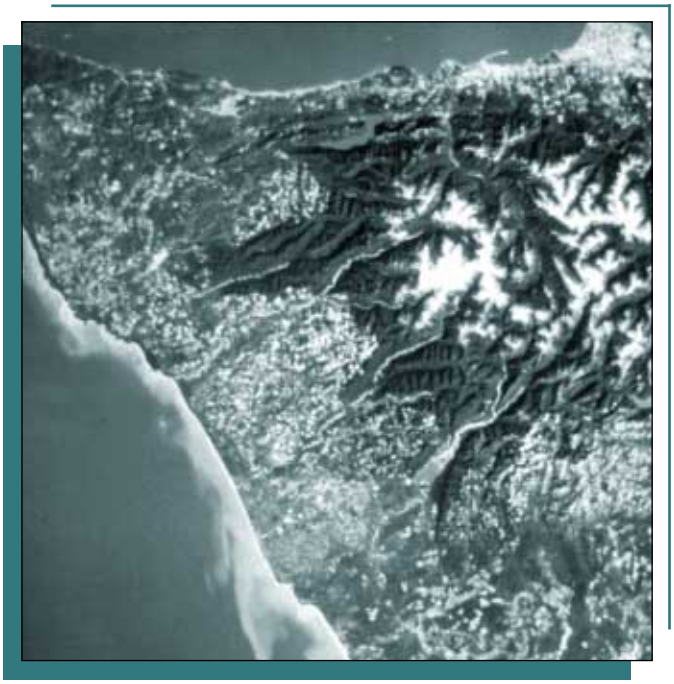
Native to eastern forests, the barred owl (*Strix varia*) has moved into the Pacific Northwest over the last several decades, likely as a result of human-caused changes in the landscape. The barred owl is closely related to the threatened northern spotted owl (*Strix occidentalis caurina*, the subspecies found in Olympic National Park, Washington), but is larger, more aggressive, and better adapted to a range of habitats. As recently as 10 years ago, the barred owl was rare in Olympic, found mostly adjacent to logged areas along the park boundary and in broad, naturally disturbed river floodplains at lower elevations. During monitoring activities in 2000, crews documented barred owls at 18 sites, many of which formerly supported northern spotted owls. More than 10 of the 53 currently monitored northern spotted owl sites are now unoccupied, or the northern spotted owls were displaced 750 meters or more following the first documented use of the site by the barred owl. This biological invasion may prove to be the primary threat to the northern spotted owl in otherwise protected landscapes such as national parks.

As with many of the more subtle ecological changes occurring in parks, the extent of this problem was revealed by a long-term monitoring program, in this case one focused primarily on another question. In 1993, President Clinton released the Northwest Forest Plan to address disagreements about the management of federal forestlands in the Pacific Northwest. The plan mandates "effectiveness monitoring" to measure whether the various federal entities are achieving the goal of protecting enough habitat to support viable populations of

species that are dependent upon late-successional forest. Northern spotted owl monitoring sites within the park, together with those monitored by the USDA Forest Service on the Olympic Peninsula, constitute the Olympic Demographic Study Area. This is one of eight study areas where rates of reproduction and survival are being



▲ **Human-caused changes in the landscape** surrounding Olympic National Park, Washington, may be facilitating a park invasion of barred owls, a competitor of the federally threatened northern spotted owl.
◀ **Owl monitoring in the park** in 2000 documented the highest number of locales supporting the barred owl since monitoring began over 10 years ago. The satellite image above reveals forest clear-cuts as light areas surrounding the park.

investigated throughout the range of the northern spotted owl through 2002. In 2002, planners hope to replace this intensive and costly monitoring with a model that would predict trends in northern spotted owl populations by tracking changes in habitat. The barred owl complicates these efforts by increasing the uncertainty surrounding estimates of northern spotted owl numbers in protected forests. Future monitoring at Olympic will address factors that predict which northern spotted owl sites are most vulnerable to displacement. This will allow barred owl competition to be incorporated into future habitat models.

Although designed to monitor demographic rates, this long-term study also offers insight into the natural history of the northern spotted owl. Olympic National Park contains the largest unfragmented area of suitable habitat within the range of this species. As such, it provides an exceptional control area against which to compare more highly managed forests and to test hypotheses about the effects of barred owl competition.

Return of the muskox to Gates of the Arctic

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They are solid creatures with a slight hump at the shoulders. Their necks, legs, and tails are short. Their dark brown, coarse guard hairs hang almost to the ground, shedding rain and snow. Neither cold nor frost can penetrate their dense inner coat of fine, soft, light brown hair. They stand approximately 4 to 5 feet tall at the shoulders and weigh from 440 to 900 pounds. Both sexes have broad horns that curve down and outward. They are muskoxen (*Ovibos moschatus*), creatures of bitterly cold and often forbidding environments, and they are beginning to occupy new habitat in Gates of the Arctic National Park and Preserve, Alaska.

One of the mandates of the National Park Service is the maintenance of a full complement of native species in national parks. But by the middle of the 19th century, muskoxen were extirpated from northern Alaska, including the park and preserve. Anecdotal information indicates that small numbers of muskoxen in the mountains and foothills of the Brooks Range were the last to disappear from the state. The species was reintroduced into northeastern Alaska in 1969 and 1970, and the released population expanded rapidly; today the animals generally occur in arctic coastal regions in the state. Since 1989, however, muskoxen have been observed with increasing frequency in Gates of the Arctic National Park and Preserve.

The reestablishment of muskox populations has been controversial in northern Alaska. Many people perceive the return of this species to historical ranges as an exciting event that affords visitors and residents the opportunity to observe this distinctive animal. Many local residents regard the muskox as a traditionally hunted resource. At the same time, many residents have expressed concern that the presence of the muskox will have a detrimental effect on caribou (*Rangifer tarandus*) populations and caribou hunting.

The natural reestablishment and harmonious integration of the muskox in Gates of the Arctic National Park and Preserve require baseline information for park managers. However, information on habitat use by muskoxen on the arctic coastal plain, with its low snow levels, may not be applicable in the alpine environment of Gates of the Arctic with higher snow levels. Information on the species' occupancy of alpine areas is limited to one study in Norway.

"The natural reestablishment and harmonious integration of the muskox in ... the park ... require baseline information for park managers."

Muskox habitat use in the park is being investigated using a geographic information system. In 2000 the locations of animals observed by park biologists and park visitors were mapped. Land cover, elevation, slope, and aspect were quantified. Initial data suggest that muskoxen occupy mountain drainages when snow is shallow and that they likely move up onto windswept mountain shoulders as snow accumulates in the drainages. The next task for park staff is mapping all muskox habitat in the park. All of the information will be used to evaluate the potential for a viable muskox population in the park, to guide management, to set future harvest levels, and to allow the National Park Service's informed participation in meetings with local, state, and federal wildlife agencies.

The National Park Service is a member of interagency and international working groups that formed to synchronize management of muskox in northern Alaska and the northern Yukon. Baseline information on habitat and distribution of the species is essential for establishing common goals of cooperative management and for addressing all concerns.

▲ **A large herd of muskox** forms a defensive circle along the coastal plain in Bering Land Bridge National Preserve, Alaska, providing a degree of safety from predators. Fewer in number in the mountainous Gates of the Arctic National Park and Preserve, the species is just beginning to occupy mountain drainages and windswept mountain shoulders in this park, prompting habitat use surveys coordinated by the National Park Service.

Paleontological inventories unearth the remains of ancient life in parks

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From the badlands near the U.S.–Mexico border to the coastline of Alaska, park staff, scientists, students, and others conducted paleontological resource inventories in 32 units of the national park system in 2000. Working in teams, the partners collected information that has advanced the knowledge of park managers regarding these nonrenewable resources and their protection. The surveys were funded by the Inventory and Monitoring Program, the Geologists-in-the-Parks Program, and the Alaska Regional Office.

Preliminary paleontological resource surveys were completed in all of the national park units in Colorado and Utah. Intensive fossil inventories initiated at Arches National Park, Glen Canyon National Recreation Area, and Zion National Park yielded some exciting new discoveries. Dozens of dinosaur track sites, containing new track types, were documented in remote canyons at both Arches and Zion.

"In Texas the largest and most complete skeleton of the sauropod dinosaur Alamosaurus *was discovered in late Cretaceous sediments at Big Bend National Park."*

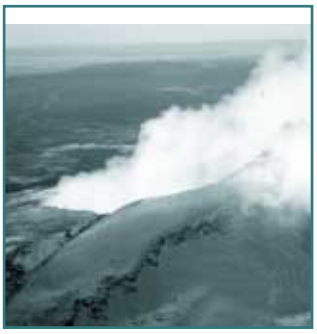
A small team of paleontologists in Alaska overcame the limitations of weather, bears, and transportation to remote locations, and initiated field surveys by foot, car, boat, and plane in four parks. Among the many new discoveries is a fossil leaf locality at Katmai National Park and a rich concentration of marine invertebrates and plants along the coastline of Aniakchak National Monument and Preserve.

In Texas the largest and most complete skeleton of the sauropod dinosaur *Alamosaurus* was discovered in late Cretaceous sediments at Big Bend National Park. Additionally, paleontological resource surveys were undertaken at Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument as part of the oil and gas management planning for both areas. This is the first time that the National Park Service has incorporated paleontological resources into oil and gas management planning and an environmental impact statement.

In addition to the surveys completed in the national park system, NPS staff assisted other federal land management agencies. The NPS approach to inventorying paleontological resources, as piloted at Yellowstone National Park in 1998 and continued with great productivity in other parks in 2000, has been recognized as a highly effective way of documenting the fossil record preserved on public lands. During 2000 the Bureau of Reclamation partnered with the National Park Service to complete paleontological surveys at Red Fleet and Steinaker Reservoirs near Vernal, Utah.

▲ **Vertebrae of a brontosaurus-like dinosaur** (i.e., sauropod) were among the discoveries at Arches National Park, Utah, during a recent paleontological resource survey by the National Park Service. This survey and similar ones conducted at Big Bend and several Utah, Colorado, and Alaska parks in 2000 have significantly advanced the knowledge of these resources and the need for their protection.

Sulfur dioxide advisory system installed at Hawaii Volcanoes



▲ **The Pu'u 'O'o vent on the east rift** zone of Kilauea Volcano currently emits approximately 1,500 tons of sulfur dioxide (SO_2) gas each day. In 2000 the Park Service and the U.S. Geological Survey began developing an SO_2 advisory system at Hawaii Volcanoes National Park to warn staff and visitors of unhealthy levels of the toxic gas.

U.S. Geological Survey

Hawaii Volcanoes National Park is unique in the national park system because it periodically has extremely high concentrations of sulfur dioxide (SO_2)—far higher than any other national park or even most urban areas. Sulfur dioxide is a poisonous gas that irritates the skin and mucous membranes of the eyes, nose, throat, and lungs. The SO_2 gas is emitted by the Kilauea Volcano, which has produced a steady flow of lava and gas since 1986. During the winter months when tradewinds are absent, high concentrations of SO_2 often occur at Kilauea's summit, impacting the popular Kilauea Visitor Center and Jaggar Museum.

To help protect the health and safety of park visitors and employees, in 2000 an SO_2 monitoring station was installed in the highly visited summit area of the park, and a notification and response plan was developed. The project was a cooperative venture among the NPS Air Resources Division, the NPS Pacific West Region Air Quality Coordinator, Hawaii Volcanoes National Park, and the U.S. Geological Survey's Hawaiian Volcano Observatory. The sulfur dioxide response plan identifies a list of actions to take when SO_2 concentrations reach defined levels for specified lengths of time. The primary intent of the response plan is to advise people about the SO_2 hazard and to recommend measures for limiting or avoiding exposure. The response plan is currently in a trial period with changes and refinements to be made as needed. The new advisory system allows the Park Service to be proactive in efforts to protect visitor and employee health and safety during periods of volcanic air pollution.

Beaver, river otter, and muskrat inventoried in Grand Canyon

Relatively little has been published about the distribution and abundance of beaver *(Castor canadensis),* river otter *(Lutra canadensis),* and muskrat *(Ondatra zibethicus)* in the Grand Canyon and their relationships with the riparian habitats along the Colorado River. This lack of information has made it difficult for wildlife managers to know how these species are faring in the park.

In spring 2000, Grand Canyon wildlife biologists took advantage of a scheduled decrease in the river's flow to conduct the first furbearer survey along the Colorado River from Lee's Ferry to Pearce Ferry. Nearly 300 miles of riverine habitat was inventoried by park biologists and more than 20 interagency volunteers from as far away as Washington, D.C., and Yellowstone National Park. With flow rates below 8,000 cubic feet per second, bank dens, slides, and tracks belonging to riparian mammals were well exposed, offering clear and accurate observations of active and inactive furbearer dens. Nearly 300 beaver dens were recorded, muskrat and otter tracks were identified, and bank vegetation was identified and mapped. All of this information was entered into a geographic information system database. The resulting data are being compiled for inclusion in a feasibility study for reintroduction of the river otter into Grand Canyon National Park, which the park hopes to complete by 2002.

Although one pair of otter tracks was observed in the survey, a viable population of the species no longer exists in the Colorado River below Glen Canyon Dam. The park staff plan to work cooperatively with local tribes, adjacent land management agencies, and local environmental groups to restore this important carnivore to the river ecosystem.

▲ **A beaver at Tapeats Creek** was one of the furbearing mammals inventoried along the Colorado River in Grand Canyon National Park in 2000.